IFT17

GO WITH PURPOSE

Meal Replacement Mass Reduction Integration and Acceptability Study

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Space Food Systems Laboratory

- JSC food lab - responsible for providing food for manned space exploration

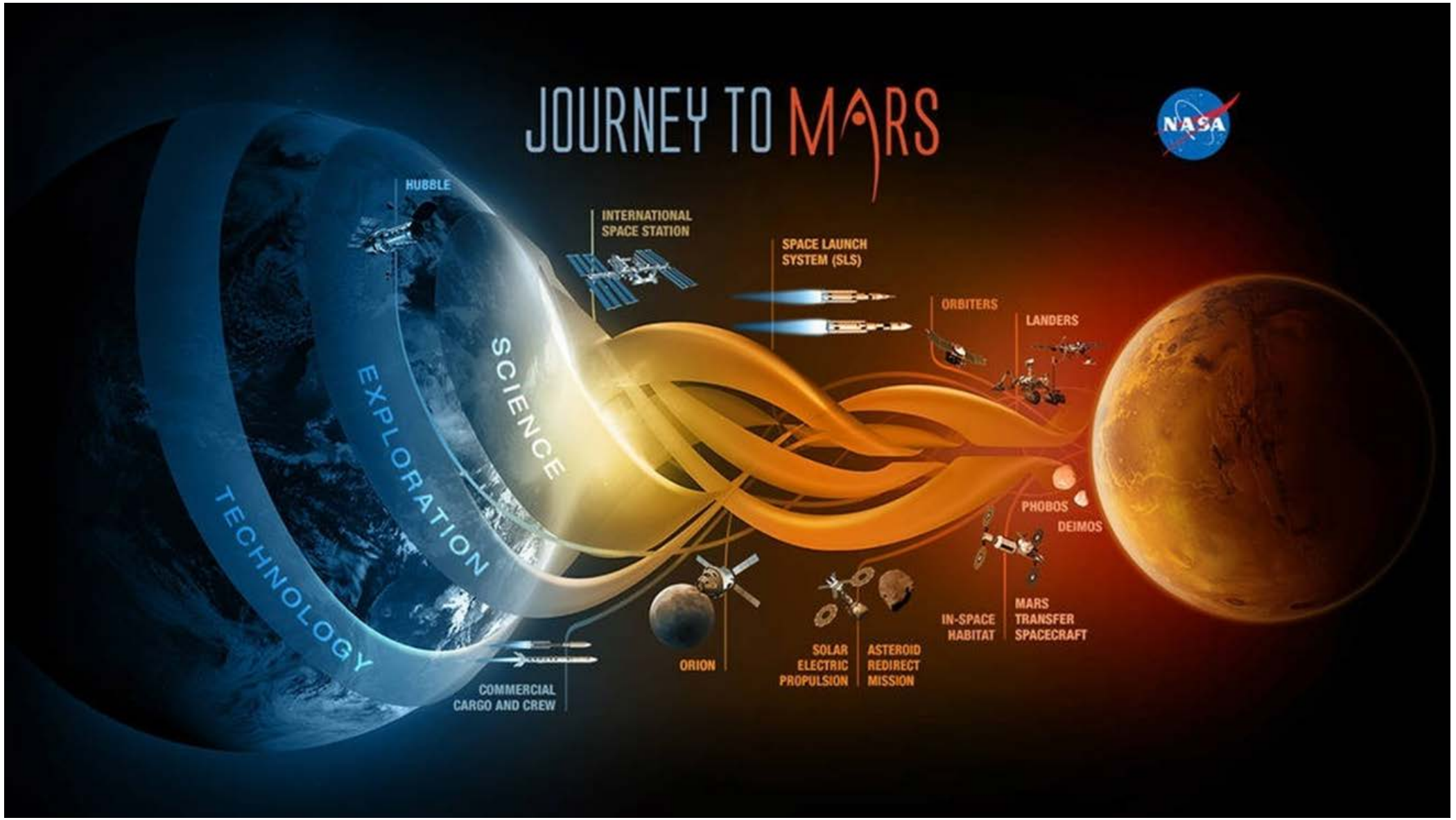
- Advanced Food Technology - developing foods for Orion and Mars exploration

Current Food System

- ISS menu has over 200 menu items
  - Thermostabilized
  - Freeze Dried
  - Natural Form

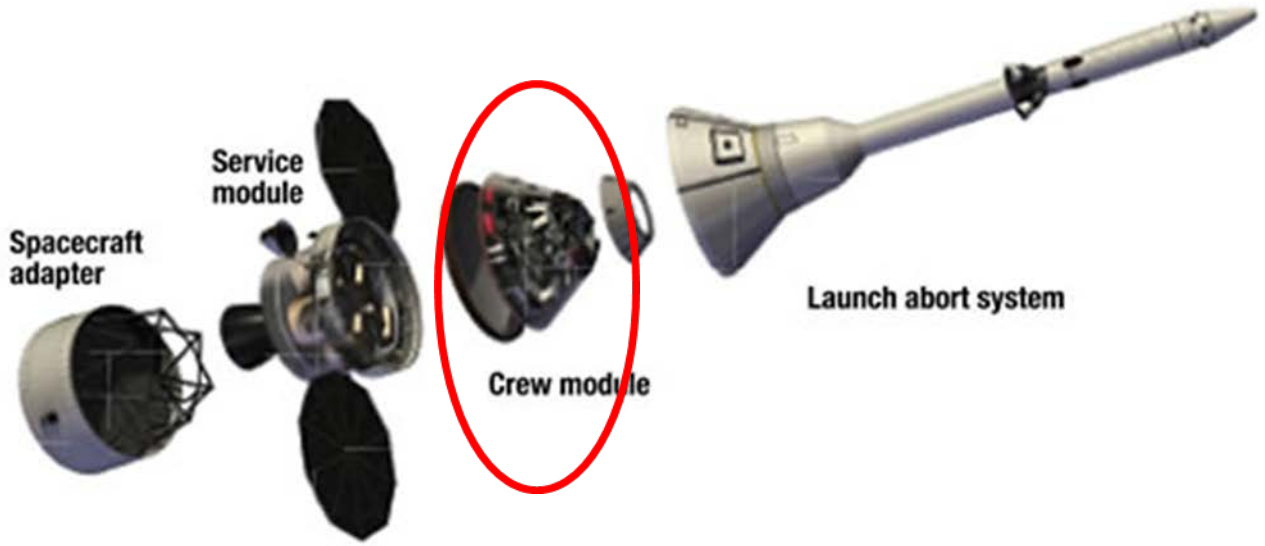
- Astronauts eat “pantry-style”

Future Space Exploration



Future Space Exploration

- Orion vehicle is mass and volume constrained with no resupply
  - -Must achieve a 10% mass reduction across the food system
  - -High-calorie meal replacement bars are the best option



Study Aims

- Develop calorically dense meal replacement bars that achieve a 10% mass reduction
- Assess bar stability over 2 years
- Determine an acceptable implementation schedule using Human Exploration Research Analog (HERA)
  - What's the long-term acceptability of the bars?
  - Is the selection acceptable?

Carver Press

Ultrasonic Press

Bar Variety

	Savory	Sweet	Chocolate	Fruity	Cake Bar	Nut Bar
Banana Nut		X			X	
Chocolate Peanut Butter			X		X	
Cinnamon Roll		X			X	
Ginger Vanilla		X			X	
Hickory Smoked BBQ	X					X
Jalapeno Nut	X					X
Maple Bacon	X	X				X
Orange Cranberry				X	X	

Sample #

Ginger Vanilla Bar
701.6 kcal per serving
4.3 kcal/g

Banana Nut Bar
702.4 kcal per serving
4.08 kcal/g

Orange Cranberry Bar
704.4 kcal per serving
4.1 kcal/g

Cinnamon Roll Bar
701.1 kcal per serving
4.0 kcal/g

Jalapeño Nut Bar
700.9 kcal per serving
3.8 kcal/g

BBQ Nut Bar
702.5 kcal per serving
3.9 kcal/g

Maple Bacon Nut Bar
700.7 kcal per serving
3.8 kcal/g

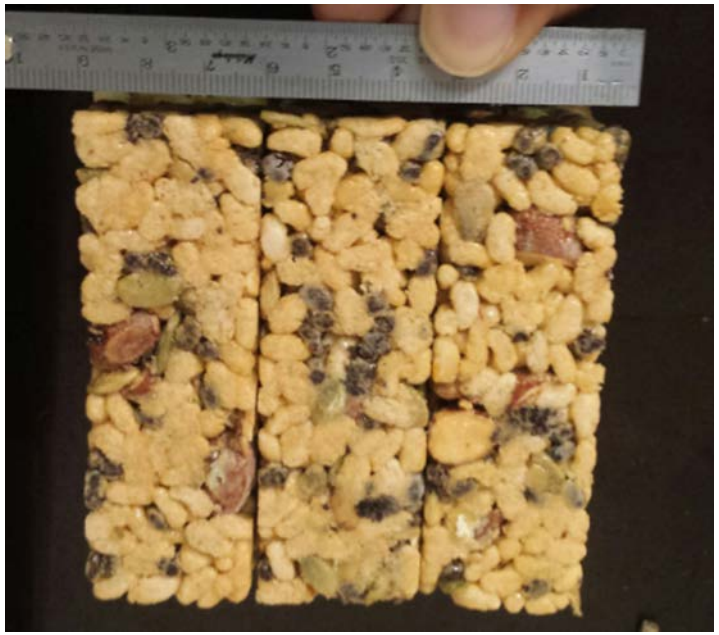
Peanut Butter Chocolate Bar*
711.2 kcal per serving
4.4 kcal/g

Sample #

Banana Nut – Carver Press

Banana Nut – Ultrasonic Press

Carver Press – Nut Bar



Ultrasonic Press- Nut Bar

Sample #

Average Bar Nutrition

- Macronutrients
  - On average, bars contain about 22.8 g protein, 88.5 g carbohydrate, 29.5 g fat
- Vitamins
  - Bars were low in folic acid, thiamin, vitamin B12, vitamin C, vitamin K1, calcium, and potassium (Banana Nut Bar was fortified with a vitamin premix)
- Minerals
  - Sodium content of overall food system decreased by ~200 mg per day with meal bars

Nutritional Comparisons

	ISS Standard Menu	Meal Replacement Menu
Calories (kcal)	2199	2310
Carbohydrates (g)	297	294
Protein (g)	116	120
Saturated Fat (g)	27	24
Fat (g)	71	81
Fiber (g)	29	31
Calcium	819	721
Potassium (mg)	3485	3578
Sodium (mg)	2722	2496
Macronutrient Profile	52% Carbs	50% Carbs
	20% Protein	20% Protein
	28% Fat	30% Fat

Initial Sensory Acceptability Scores

	Overall	Appearance	Color	Aroma	Flavor	Texture
Banana Nut (UC)	7.45	7.33	7.36	7.45	7.36	7.36
Orange Cranberry (UC)	7.33	7.67	7.52	7.15	7.36	7.67
Ginger Vanilla (TC)	7.23	7.17	7.31	6.97	7.17	7.43
Jalapeno Nut (TC)	7.11	7.08	7.00	6.56	7.25	6.92
Banana Nut (TC)	6.91	6.23	6.83	7.11	7.03	5.86
Honey BBQ Nut (TC)	6.50	7.14	7.00	6.44	6.25	7.19

Sample #

Oil Loss

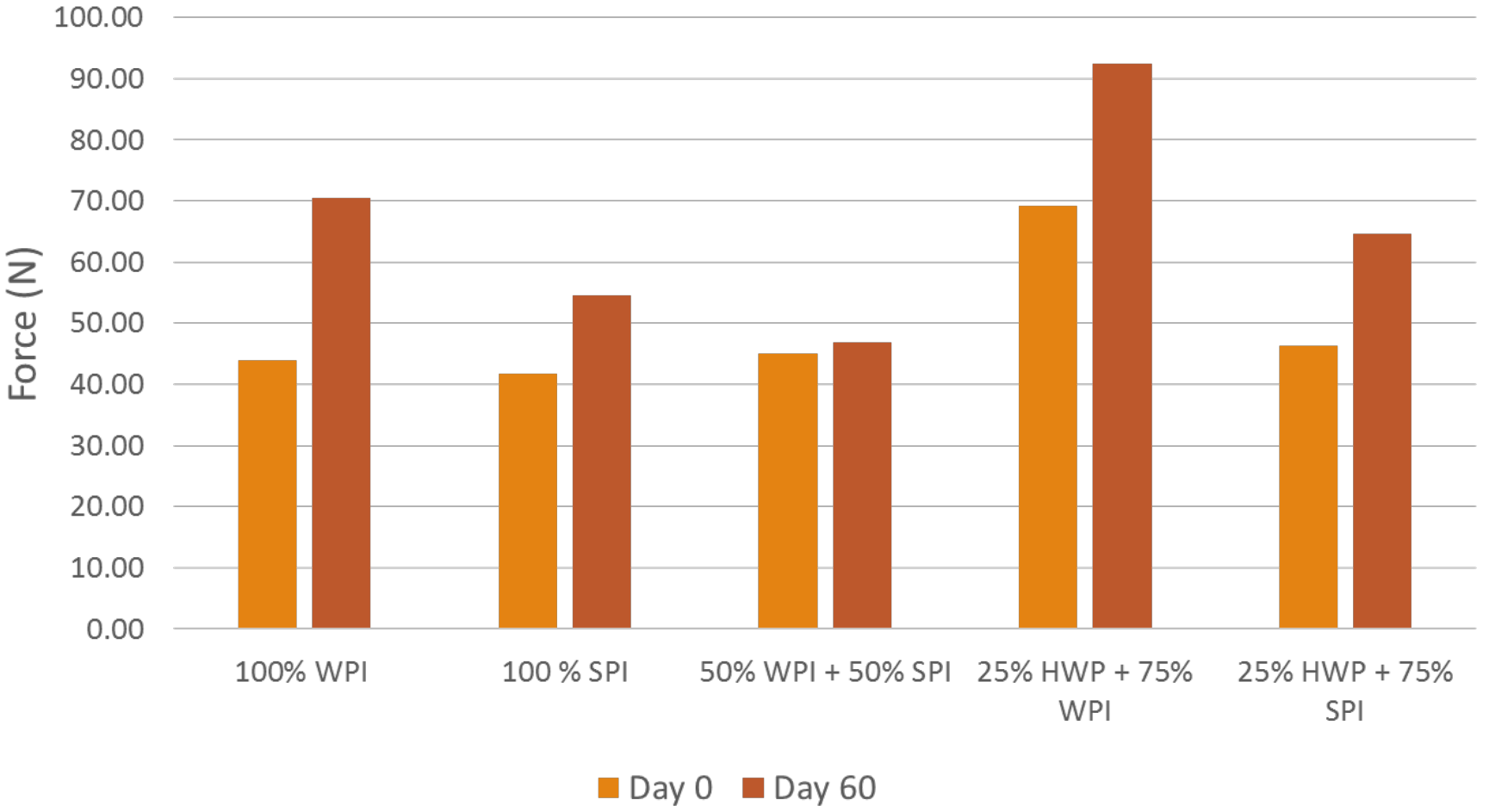
HWP + SPI

100%SPI

Texture

- Bar hardening is the most common mode of failure
- Moisture migration and protein : protein interactions
- Can be minimized by proper protein selection

Effects of Protein Type on Bar Hardening

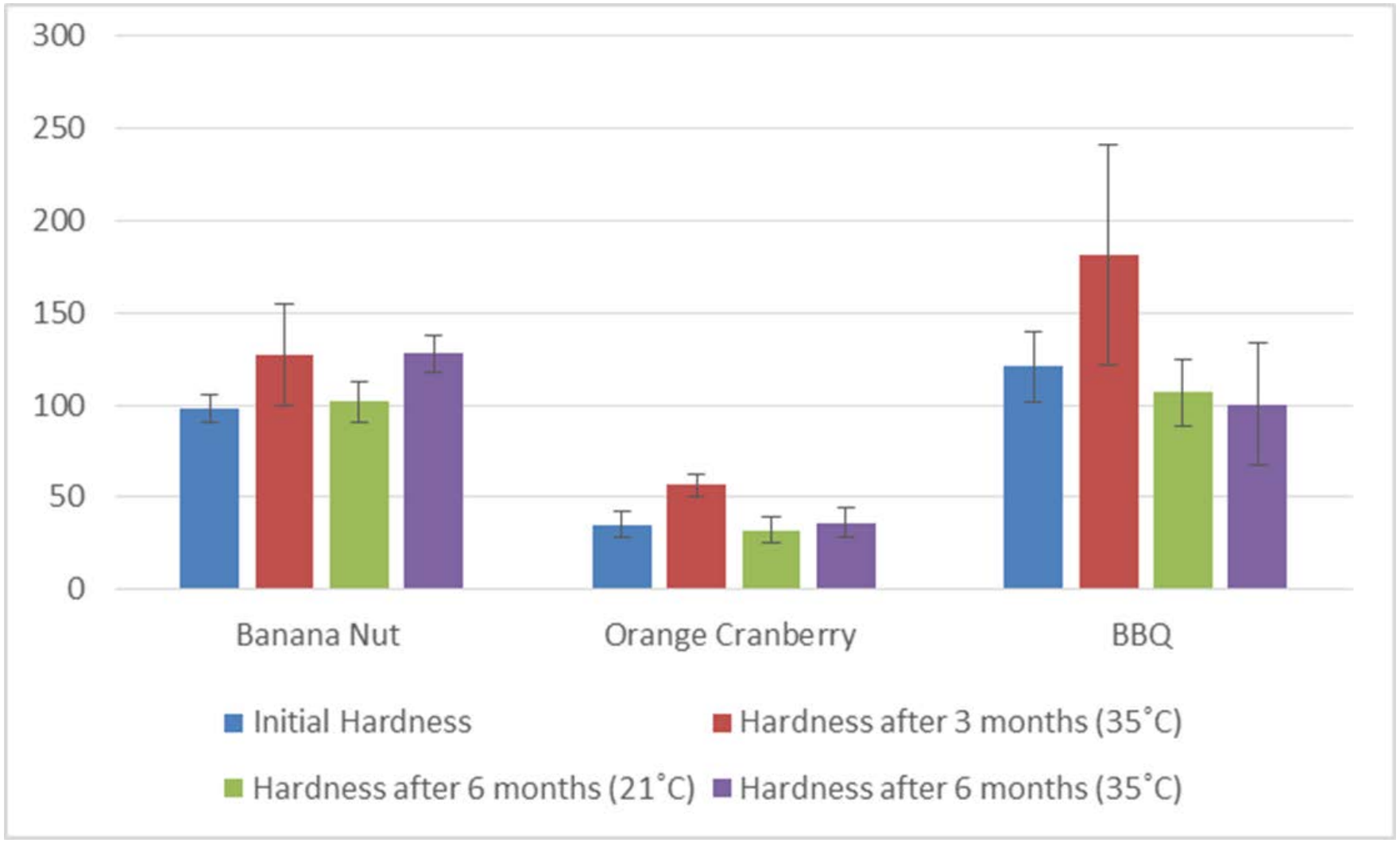


Sample #

Ginger Vanilla Bar- 35˚C

Bar	Protein Type
Jalapeno Nut Bar	Whey protein powder and Soy protein nugget
Banana Nut Bar	Vanilla whey protein concentrate
BBQ Nut Bar	Whey protein powder and soy protein nugget
Orange Cranberry Bar	Whey Protein Powder (Industrial)
Ginger Vanilla Bar	Soy Protein Powder

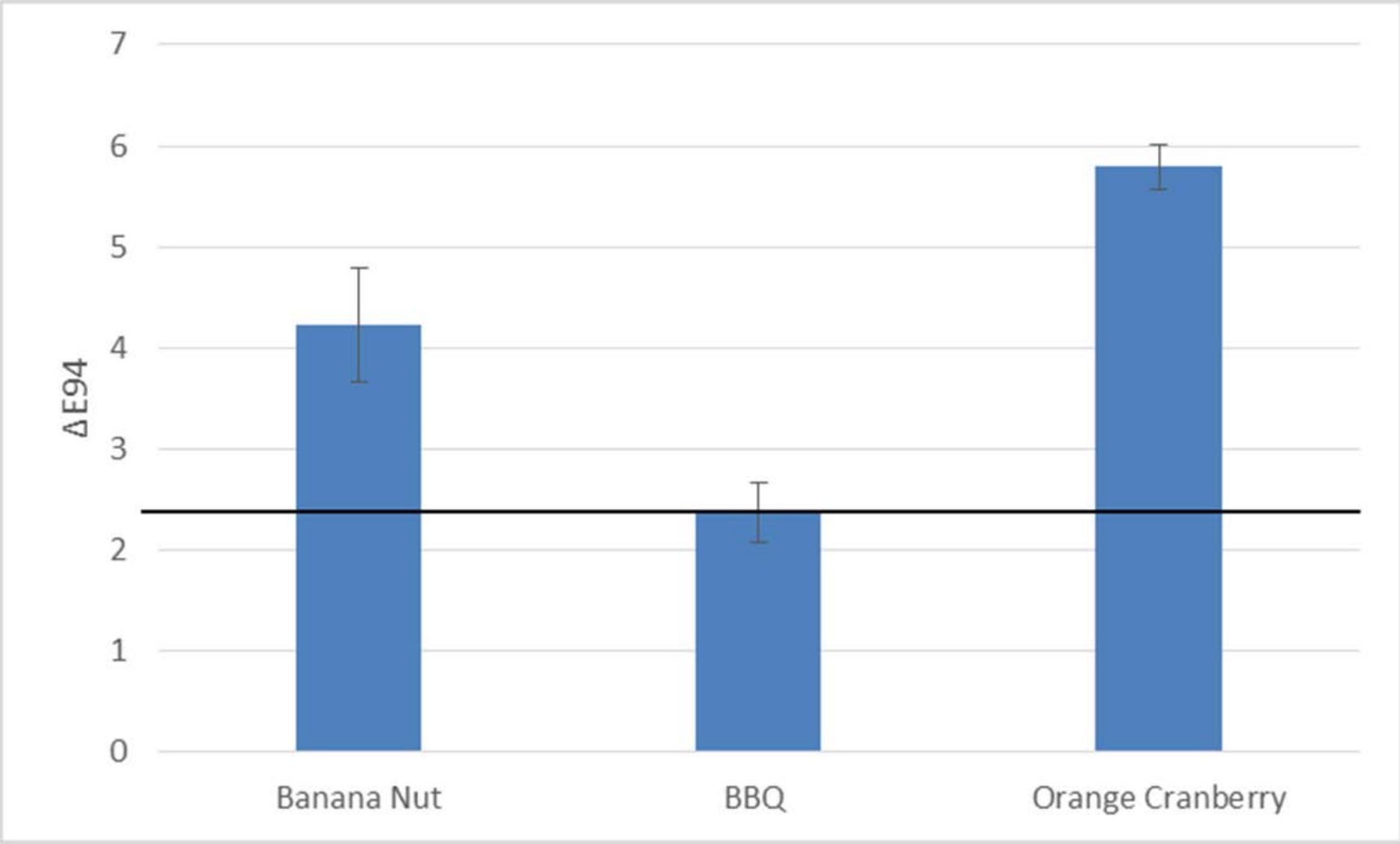
Texture Change Over Time



Sample #

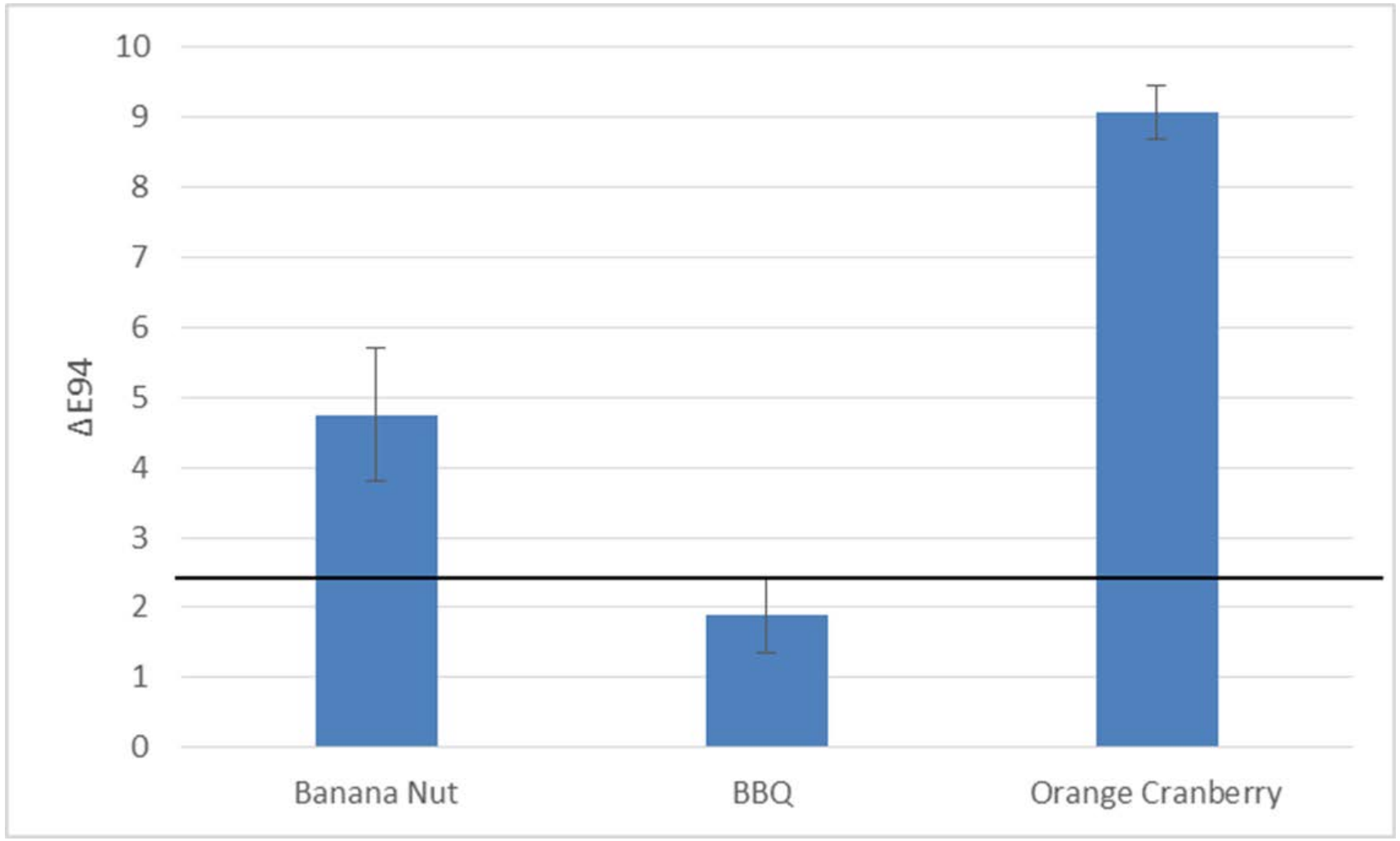
Sample #

Color Change after 3 mo (35˚C)



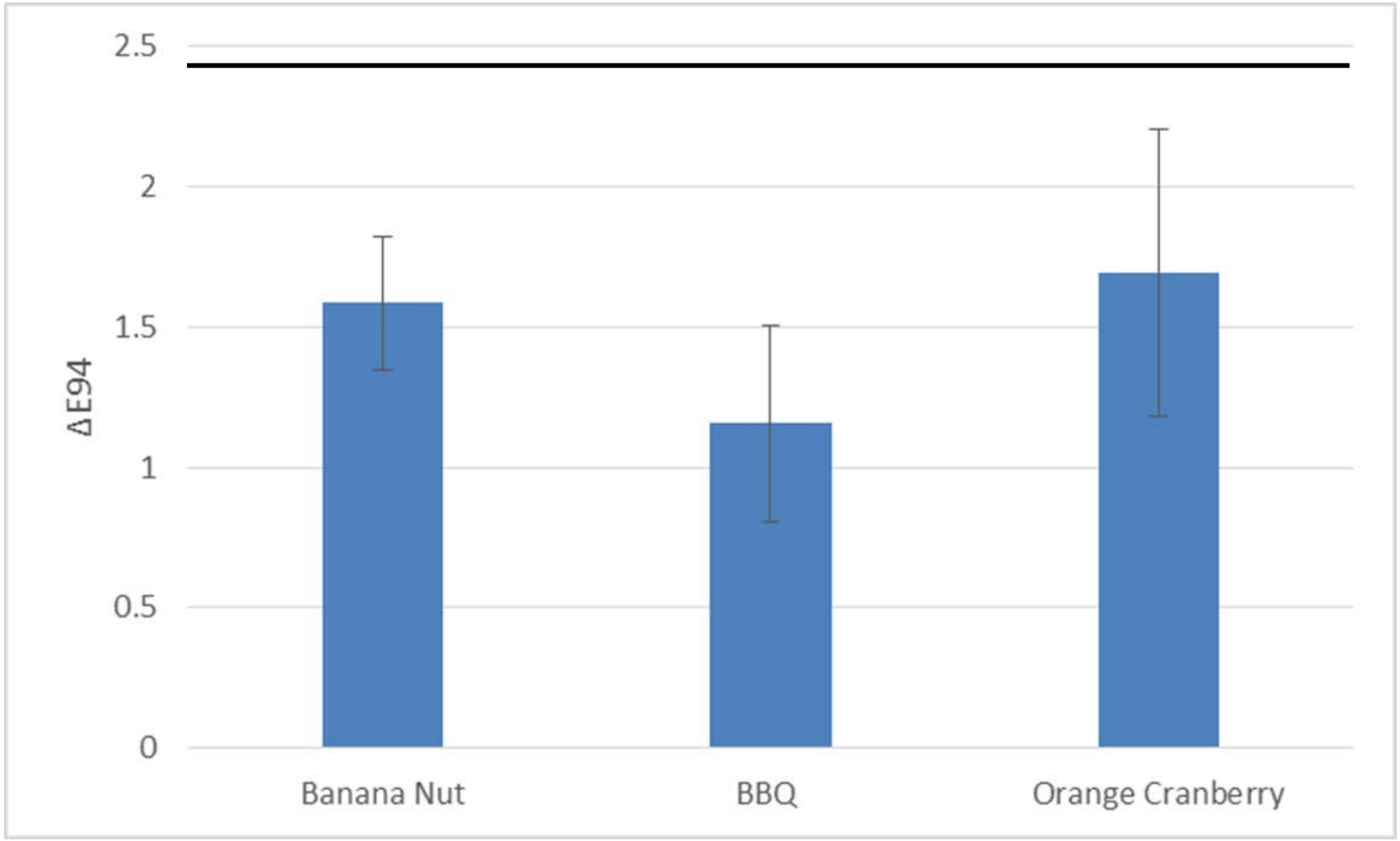
Sample #

Color Change after 6 mo (35˚C)

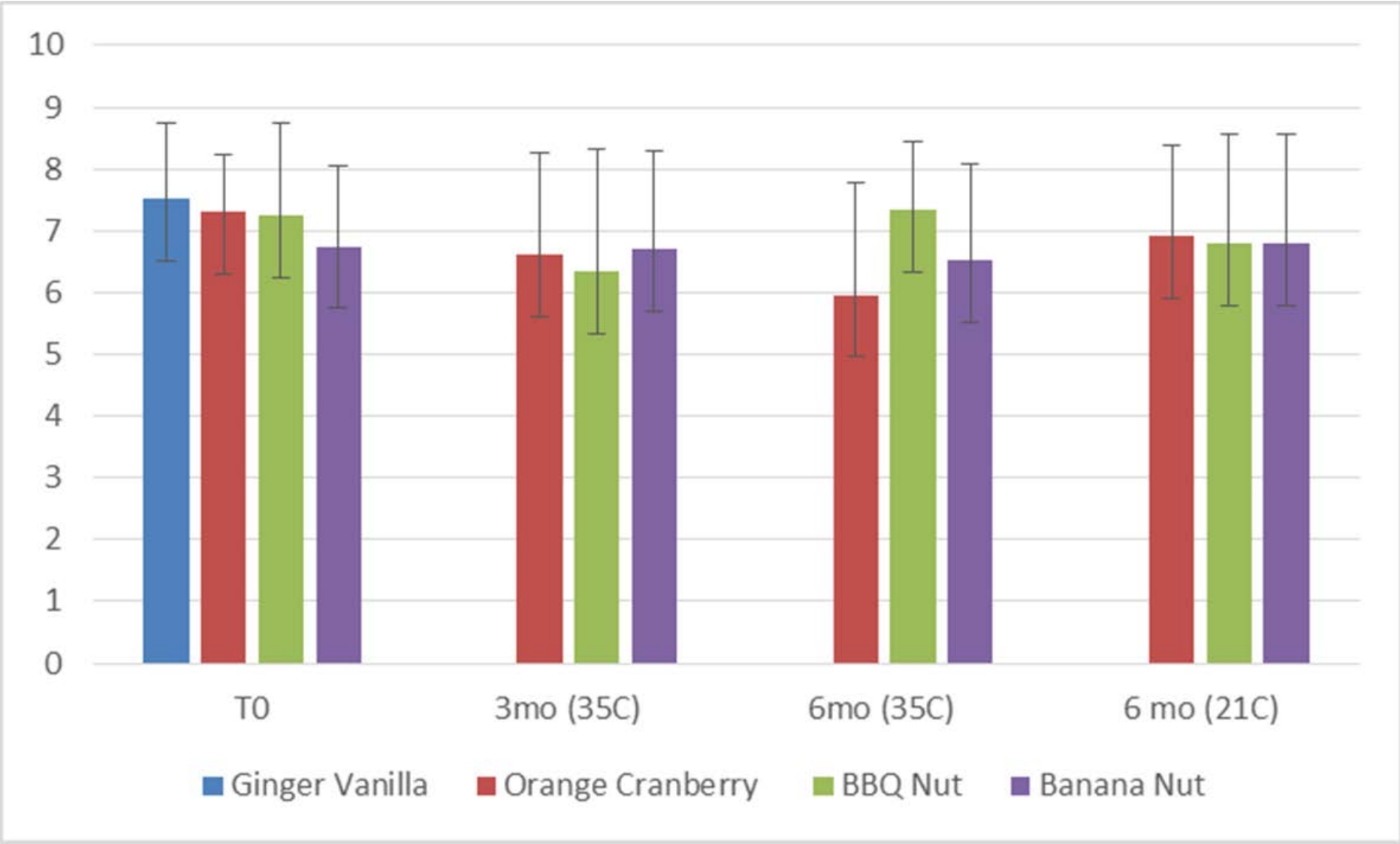


Sample #

Color Change after 6 mo (21˚C)



Overall Acceptability Over Time



HERA

- n= 16

- Crews were provided with equal amounts of each bar
  - Bars everyday for the first 15 days
  - Bars every three days for the second half of the mission

- Crew feedback was recorded in daily surveys and post-mission debriefs

HERA Feedback – Acceptability

	Jalapeño Nut	BBQ Nut	Banana Nut	Orange Cranberry
Overall Acceptability	4.81 ± 2.61	5.25 ± 2.41	6.31 ±2.09	7.31 ± 1.85
Appearance	6.69 ± 1.62	6.13 ± 2.13	6.44 ± 1.09	7.06 ± 1.48
Color	6.31 ± 1.49	6.19 ± 1.64	6.31 ± 1.20	7.00 ± 1.37
Aroma	5.56 ± 2.37	5.88 ± 2.22	6.69 ± 1.66	7.44 ± 1.55
Flavor	4.75 ± 2.77	5.50 ± 2.5	6.50 ± 1.97	7.25 ± 1.69
Texture	4.81 ± 2.86	5.00 ± 2.63	6.50 ± 1.60	7.19 ± 1.52

Sample #

Carver Press

Ultrasonic Press

Sample #

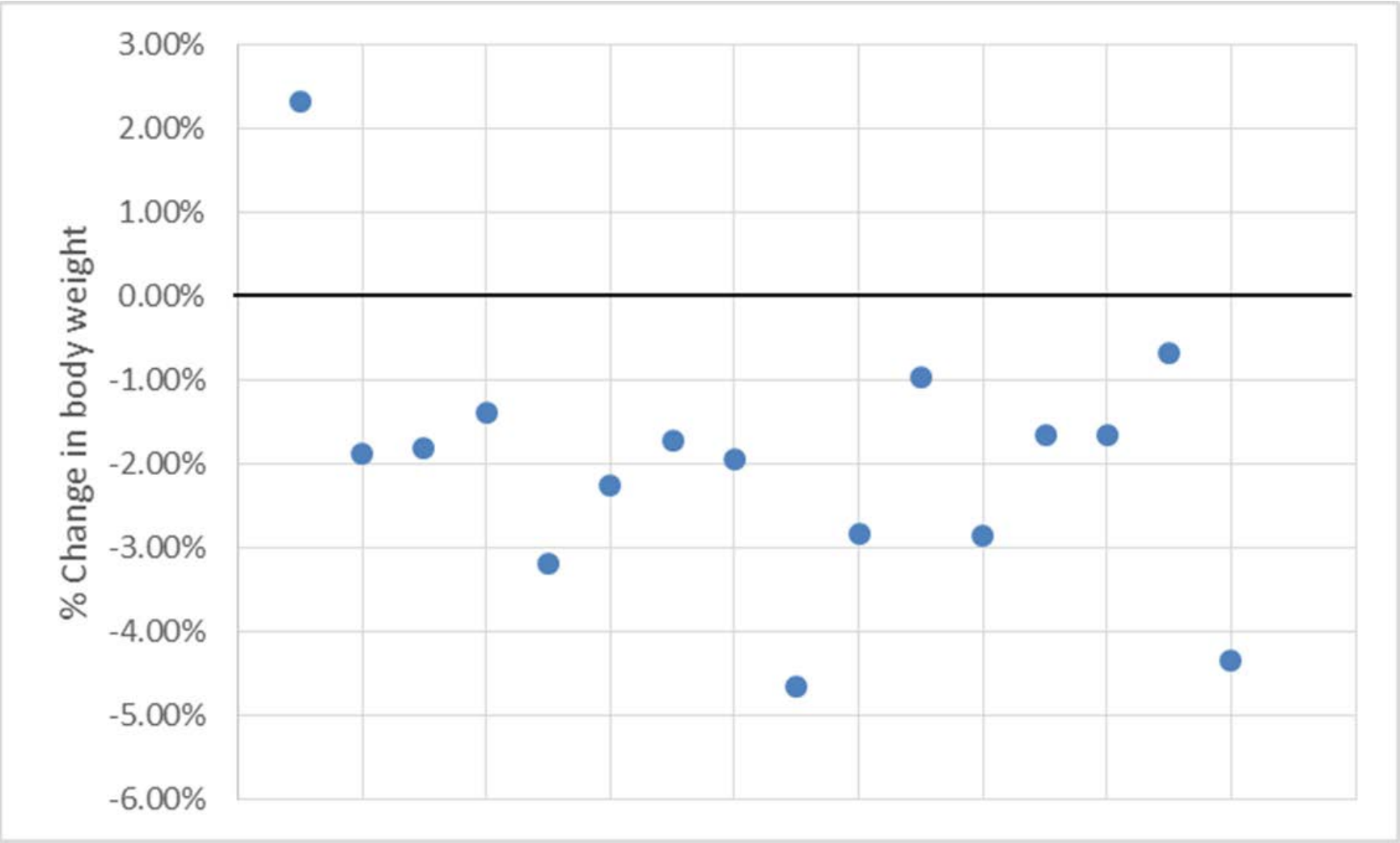
HERA Feedback- Variety

- Selection is inadequate for mission length
- Pre-mission evaluation was not helpful for selecting bars
- Bar fatigue was evident by crew's tendency to trade or avoid bars
- Increased variety can improve meal replacement bar acceptability

HERA Feedback – “Eat- to- Zero”

- EER calculation was used to predict caloric need and may have over- / under-estimated calories
- Typically too much food
  - Crewmembers used extra food to supplement variety
  - Several bags of unused food
- A few instances of not enough food

Crew Body Weight



Key Findings

- Ultrasonic bars are slightly more favorable than traditional bars
- Overall acceptability is maintained through first two months of shelf-life
- Fortification is required to satisfy vitamin requirements